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Validation of the LASA fall risk profile for recurrent falling in older recent fallers

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Abstract

Objectives: The fall risk profile developed in the Longitudinal Aging Study Amsterdam (LASA) identifies community-dwelling elderly at high risk for recurrent falling. This study assessed the predictive validity of this profile in older persons seeking care after a fall.

Study Design and Setting: The LASA fall risk profile was completed for 408 persons of 65 years and older who consulted the emergency department or general practitioner after a fall. Falls were prospectively reported with a calendar during 1 year. Recurrent falling was defined as ⩾2 falls within a period of 6 months.

Results: During 1 year of followup, 76 (18.6%) participants became recurrent fallers. The area under the receiver operating characteristic curve was 0.65 (95% confidence interval [95% CI]: 0.58−0.72). At a cutoff value of 8, the sensitivity was 56.6% (CI: 51.8−61.4), the specificity was 71.4% (CI: 67.0−75.8), the positive predictive value was 34.1% (CI: 29.5−38.7), and the negative predictive value was 85.6% (CI: 82.2−89.0).

Conclusion: The discriminative ability of the LASA fall risk profile was moderate. The predictive validity of the LASA fall risk profile to identify recurrent fallers is limited among older persons who consulted the emergency department or general practitioner after a fall.

Keywords: Risk assessment; Accidental falls; Recurrent falling; Predictive validity; Old age; Fall risk

1. Introduction

Falling is a major health problem in old age. About 30% of community-dwelling persons of 65 years and older fall once a year and 15% fall at least twice a year [1−3]. The consequences of falling are severe: 5% of all falls lead to a fracture and 5% lead to other serious injuries [4]. About 20−25% of all fallers and 50% of all injurious fallers consult a hospital emergency room or general practitioner after the fall [4−6].

Because of the increasing number of older persons in the next decades, the number of older persons with falls is expected to rise as well. Even with maximum expansion of primary care and geriatric health care resources, treatment of every older person to prevent further falls is not feasible. Some interventions, such as home modifications, appear to be more effective in high-risk populations [7], whereas other interventions, such as exercise, may be more effective in unselected populations [8]. Probably different interventions are required in older persons with a high and low risk of falling. To identify persons with a low or high risk of falling, a risk profile can be used.

Several risk profiles for identifying community-dwelling older persons at high risk of falling have been developed [9−14]. It is known that the accuracy of prediction models differs in populations with different characteristics. Therefore, validation of risk profiles in other populations is necessary to assess the generalizability [15]. To our knowledge, only one of these risk profiles, the FROP-com (Fall Risk for Older People in the Community assessment), has been validated in populations who presented themselves after a fall [14]. However, the FROP-Com predicts the risk of falling rather than the risk of recurrent falling. In the literature, a distinction is made between once-fallers and recurrent fallers [16,17]. A single fall may be coincidental and may be caused mainly by environmental factors, whereas recurrent falls usually are caused by physical, cognitive, and behavioral

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What is new?

- The predictive validity of the LASA fall risk profile to identify recurrent fallers is limited among older persons who consulted the emergency department or general practitioner after a fall.
- Internationally, guidelines recommend focusing preventive measures on those with the highest fall risk, however, existing risk profiles have limited predictive validity.
- Further research should focus on the validity of other fall risk profiles and compare their predictive validity with clinical judgment.

factors within the person [18]. Because the consequences of falling seem to be more severe in recurrent fallers than in once-fallers [19], we were interested in the predictive validity of risk profiles for recurrent falling.

The fall risk profile developed in the Longitudinal Aging Study Amsterdam (LASA) predicts the risk of recurrent falling in older persons [11]. This profile consists of nine items, including fall history, dizziness, functional limitations, grip strength, body weight, having a dog or cat in the household, fear of falling, alcohol intake, and level of education. Strengths of this profile are that it is easy to administer and that it has been developed in a large sample that is representative for the Dutch community-dwelling older population. The aim of the present study was to assess the predictive validity of the LASA fall risk profile in a clinically relevant population of older persons who consulted the emergency department or general practitioner after a fall. The discriminative ability of the fall risk profile was calculated to test the validity. The sensitivity, specificity, and positive and negative predictive values were calculated to explore the optimal cutoff value for triage in primary care settings.

In the LASA fall risk profile, the item ''fear of falling'' was measured using the Falls Efficacy Scale (FES) [20,21]. This item consists of 10 subquestions and is therefore not so practical for use in daily practice. In the present study, fear of falling was also measured using the question ''Are you afraid to fall.'' The risk profile may be simplified by replacing the FES by this question. The second aim of this study was to examine whether this adaptation altered the predictive validity of the risk profile.

2. Methods

2.1. Study population

Data were used from the randomized controlled trial (RCT) ''Prevention of fall incidents in older persons with a high risk of falling'' (Current Controlled Trials ISRCTN11546541). The design of this fall prevention trial (FPT) is described in detail elsewhere [22] and approved by the Medical Ethics Committee of the VU University Medical Center (VUmc), Amsterdam. In short, persons who reported themselves after a fall at the emergency department of the VUmc or their general practitioner between April 2005 and June 2007 were potential participants. Inclusion criteria were being 65 years or older, living independently or in a residential home in the vicinity of the VUmc and having had a recent fall. Exclusion criteria were inability to sign informed consent, inability to provide a fall history, or scoring less than 24 points on the Mini-Mental State Examination (assessed during the home visit explained below), presenting fall because of a traffic or occupational accident, living in a nursing home, and acute pathology requiring long-term rehabilitation, such as a stroke. Participants who signed informed consent were visited at home by trained interviewers within 3 months after the presenting fall. During the home visit, the LASA fall risk profile (Appendix: http://www.jclinepi.com) was assessed. The RCT was done among persons at high risk of recurrent falling. For the purpose of this RCT, high risk was defined as scoring eight points or more on the risk profile. This cutoff value was based on a calibration analysis in a subsample of fallers in the LASA study. Of the 2,015 persons who presented themselves after a fall at the emergency department or general practitioner, 600 signed informed consent and completed the risk profile (Fig. 1). After signing informed consent, 36 participants were excluded or refused further participation. Participants who scored eight points or more on the risk profile ($n = 217$) were randomized into an intervention ($n = 106$) or usual care group ($n = 111$). For the present study, data were used from the participants who scored less than eight points ($n = 347$) or who were assigned to the usual care group ($n = 111$). Subsequently, participants living in a residential home were excluded from the analyses ($n = 9$) because the risk profile was developed for the community-dwelling population. In addition, participants with incomplete fall followup were excluded from the analyses ($n = 41$): 8% and 14% of the low- and high-risk group had incomplete followup, respectively. Finally, data of 408 participants with complete fall followup were used in the present study.

2.2. LASA fall risk profile

The LASA fall risk profile predicts the risk of recurrent falling in older persons. Its development has been described in detail elsewhere [11]. In short, this risk profile was developed in LASA, an ongoing interdisciplinary cohort study on predictors and consequences of changes in autonomy and well-being in older persons in the Netherlands [23]. The sample was stratified by age, sex, and 5-years mortality rate and is representative for the community-dwelling Dutch older population. A subsample of 1,365 participants who were 65 years and older reported falls during 3 years

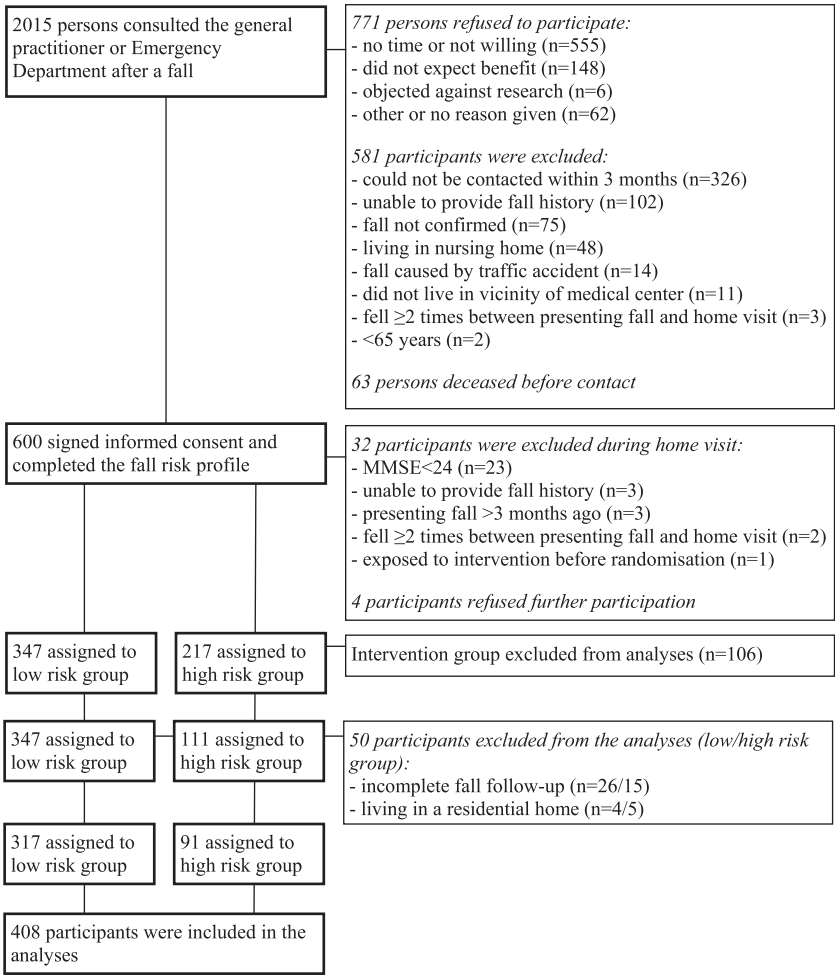

Fig. 1. Flow chart of the present study in the framework of the fall prevention trial.

(from 1995/96 to 1998/99) [11]. Backward logistic regression analyses identified nine items that predicted recurrent falling: ⩾2 falls in preceding year, regular dizziness, >2 functional limitations, poor grip strength, low body weight, having a dog or cat in the household, fear of falling, >15 glasses of alcohol, and ⩾11 years of education. Also, two interaction items were included in the profile (i.e., ⩾2 falls in preceding year × fear of falling and >15 glasses of alcohol × ⩾11 years of education). Interaction items were combinations of items that increased the probability of becoming a recurrent faller more than the sum of the separate items. A weighted score based on the multivariate odds ratio was assigned to each of the items, and the scores were summed to a total risk score (range: 0−30). For example, an 80-year-old lady who fell twice in the preceding year (4 points), who is afraid to fall again (2 points), and who owns a cat (2 points), would score four additional points for the combination of two falls in the preceding year and fear of falling. In total, she would score 10 points on the LASA fall risk profile. Higher scores indicate a higher risk of recurrent falling. The fall risk profile is included in the Appendix (http://www.jclinepi.com).

All items were measured in the same way in FPT as in LASA. Only the item ‘‘functional limitations’’ was adapted in FPT. In LASA, this item was measured by asking the level of difficulty participant had with using his/her own or public transportation, going up 15 steps without standing still, and cutting his/her own toenails. The answer categories were (1) no, I cannot; (2) only with help; (3) yes, with much difficulty; (4) yes with some difficulty; and (5) yes without help. If the participant had at least some difficulties (categories 1−4) with all three activities, three points were scored on this item. In FPT, this item was simplified by asking whether the participant do these activities independently (yes/no). If the participant answered no on all three activities, three points were scored on this item. Handgrip strength (item 4) was measured using a digital strain-gauged dynamometer (Takei TKK 5401; Takei Scientific Instruments Co. Ltd., Tokyo, Japan). Participants were instructed to put their arms along their body while maximally squeezing the handle with one hand during 2 seconds. The procedure was repeated twice per hand, and the maximum scores of each hand were summed. Body weight (item 5) was measured using a calibrated weighing

scale. Fear of falling (item 7) was measured with the FES, which consists of 10 subquestions [20,21]. Participants scored how concerned they were to fall during 10 activities (0 = not concerned at all to 3 = very concerned; range: 0−30).

2.3. Fear of falling

In FPT, fear of falling was also assessed by asking the question ''Are you afraid to fall?''. Participants indicated how afraid they were by assigning a score from 1 to 10, with a score of one indicating being ''not afraid at all'' and a score of 10 indicating being ''very afraid to fall.'' If participants scored a six or higher (75th percentile), two points were added to their total risk score.

2.4. Recurrent falling

At the home visit, the participants received a fall calendar [11]. For the period of 1 year, the participants ticked per week whether they did or did not fall during that week. A fall was defined as an unintentional change in position resulting in coming to rest at a lower level or on the ground [24]. Once every 3 months the participants returned a calendar sheet by mail. When no sheet was received or when the sheet was completed incorrectly, we inquired by telephone whether and when the participant had fallen in the past 3 months. Recurrent falling was defined as two or more falls within 6 months [11,12,25].

2.5. Statistical analysis

First, the main baseline characteristics and prevalences of the items of the fall risk profile in FPT and LASA were presented. Second, the goodness-of-fit was tested using the Hosmer−Lemeshow test in the multivariate logistic regression model ($P > 0.05$ indicates a good fit). Third, in FPT, the predictive validity was examined by calculating the following diagnostic values for each cutoff point: percentage in high-risk group (i.e., percentage of participants scoring the cutoff value or higher on the fall risk profile), sensitivity, specificity, sum of sensitivity and specificity, positive predictive value, and negative predictive value. Fourth, the area under the receiver operating characteristic (ROC) curve (AUC) and 95% confidence interval (CI) was computed to evaluate the discriminative ability of the model. Finally, to examine whether the item fear of falling could be replaced by the question ''Are you afraid to fall,'' the AUC was recalculated using this measure. All analyses were done using SPSS software (Version 15.0.0; SPSS Inc., Chicago, IL, USA).

3. Results

From the FPT, 408 participants with complete fall follow-up were included in the validation study. The mean age was 77.9 (standard deviation = 7.1) years, 73.3% was female and the median risk score was 6 (interquartile range: 3−9) (Table 1). Within 1 year of followup, 76 participants (18.6%) became recurrent fallers. Of the persons with incomplete followup, 18 could not be contacted, 14 refused further participation, and 9 died. These excluded persons ($n = 41$) were older ($P = 0.04$) and tended to score higher on the risk profile ($P = 0.08$) than the included participants but did not differ with respect to sex or living situation. Of the 408 participants included in the analyses, 36% reported two or more falls in the preceding year and 51% reported fear of falling. The Hosmer−Lemeshow goodness-of-fit test was not significant ($P = 0.99$), indicating that the model fitted the data well.

Per cutoff value, the percentages of persons in the high-risk group, sensitivity, and positive predictive values are presented in Table 2. The maximum sum of sensitivity and specificity was found at a cutoff value of 8. At a cutoff value of 8, the sensitivity was 56.6% (CI: 51.8−61.4), the specificity was 71.4% (CI: 67.0−75.8), the positive predictive value was 34.1% (CI: 29.5−38.7), and the negative predictive value was 85.6 % (CI: 82.2−89.0). Figure 2 shows the ROC curve for the FPT. The AUC was 0.65 (CI: 0.58−0.72), which indicates that 65% of the random pairs of recurrent fallers and nonrecurrent fallers would be discriminated correctly as high and low risk, respectively. Measuring the item ''fear of falling'' with the question ''Are you afraid to fall?'' instead of the FES did not affect the discriminative ability of the risk profile (AUC: 0.65, CI: 0.58−0.72).

4. Discussion

The aim of this study was to apply an existing fall risk profile to a sample of community-dwelling older persons

Table 1
Baseline characteristics and prevalence of the items of the LASA fall risk profile in the fall prevention trial

	FPT
N	408
Age (mean [standard deviation])	77.9 [7.1]
Sex (% women)	73.3
LASA fall risk profile (median [interquartile range])[a]	6 [3−9]
Enrollment (% emergency department)[b]	89.5
Items of the fall risk profile (%)	
⩾2 Falls in the preceding year	36.0
Dizziness regularly	9.1
Functional limitations (>2)	5.6
Grip strength (women ⩽32 kg; men ⩽56 kg)	40.2
Body weight (women ⩽62 kg; men ⩽70 kg)	32.6
Dogs or cats in household	14.5
Fear of falling (FES ⩾1)[c]	51.0
Alcohol use >15 glasses per week	6.4
Education ⩾11 yr	50.2
⩾2 Falls in preceding year × fear of falling	10.5
Alcohol >15 × education ⩾11 yr	2.5

Abbreviations: FPT, fall prevention trial; LASA, Longitudinal Aging Study Amsterdam; FES, Falls Efficacy Scale.

[a] LASA fall risk profile: range: 0−30.

[b] Enrollment via emergency department or general practitioner.

[c] FES: range: 0−30.

Table 2
Diagnostic values of the LASA fall risk profile in the fall prevention trial

Cutoff in the total risk score	A (*n*)	B (*n*)	C (*n*)	D (*n*)	Sensitivity (%)	Specificity (%)	∑ (%)	PV+ (%)	PV− (%)
0 vs. ⩾1	73	311	3	21	96.1	6.3	102.4	19.0	87.5
0−1 vs. ⩾2	72	287	4	45	94.7	13.6	108.3	20.1	91.8
0−2 vs. ⩾3	67	267	9	65	88.2	19.6	107.8	20.1	87.8
0−3 vs. ⩾4	63	231	13	101	82.9	30.4	113.3	21.4	88.6
0−4 vs. ⩾5	58	203	18	129	76.3	38.9	115.2	22.2	87.8
0−5 vs. ⩾6	52	157	24	175	68.4	52.7	121.1	24.9	87.9
0−6 vs. ⩾7	48	124	28	208	63.2	62.7	125.9	27.9	88.1
0−7 vs. ⩾8	43	95	33	237	56.6	71.4	127.7[a]	34.1	85.6
0−8 vs. ⩾9	35	81	41	251	46.0	75.6	121.6	30.2	86.0
0−9 vs. ⩾10	31	68	45	264	40.8	79.5	120.3	31.3	85.4
0−10 vs. ⩾11	30	58	46	274	39.5	82.5	122.0	34.1	85.6
0−11 vs. ⩾12	26	54	50	278	34.2	83.7	117.9	32.5	84.8
0−12 vs. ⩾13	25	42	51	290	32.9	87.3	120.2	37.3	85.0
0−13 vs. ⩾14	19	32	57	300	25.0	90.4	115.4	37.3	84.0
0−14 vs. ⩾15	18	28	58	304	23.6	91.6	115.2	39.1	84.0
0−15 vs. ⩾16	13	23	63	309	17.1	93.1	110.2	36.1	83.1

A, number of participants who were assigned to the high-risk group and who were recurrent fallers; B, number of participants who were assigned to the high-risk group and who were not recurrent fallers; C, number of participants who were assigned to the low-risk group and who were recurrent fallers; D, number of participants who were assigned to the low-risk group and who were not recurrent fallers; ∑ Sum of sensitivity (A/A + C) and specificity (D/B + D); PV+ Positive predictive value (A/A + B); PV− Negative predictive value (D/C + D).

Abbreviation: LASA, Longitudinal Aging Study Amsterdam.

[a] Maximal sum of sensitivity and specificity.

who consulted their general practitioner or emergency department after a fall. Although the goodness-of-fit suggested that the model fitted the data well, the discriminative ability was moderate. Approximately 65% of recurrent fallers and nonrecurrent fallers were correctly classified as high or low risk of recurrent falling, respectively. The maximal sum of sensitivity and specificity was found at a cutoff value of 8.

The current sample clearly differs from the LASA sample in which the risk profile was developed. The differences originate from differences in recruitment. The LASA sample is a relatively healthy sample of the Dutch community-dwelling older population, and no specific fall-related selection criteria were used [11]. The FPT sample, on the other hand, represents a population presenting after a fall at the emergency department or general practitioner within the vicinity of the VUmc. The differences between these samples became evident in the prevalences of the items, and consequently the different diagnostic values per cutoff value, and lower discriminative ability in FPT (AUC: 0.65, 95% CI: 0.58−0.72) as compared with LASA (AUC: 0.71, 95% CI: 0.67−0.74).

Some of the predictors are susceptible to change (e.g., weight and grip strength) and thus the risk score may change over time. Consequently, the risk profile may be more accurate in predicting recurrent falling on the short-term than on the long-term. To test this, the diagnostic values and AUC were also calculated in the FPT with recurrent falling measured during 6 months of followup. As compared with 1 year of followup in the FPT, the sensitivity and negative predicted values were indeed slightly higher and the specificity and positive predictive values were indeed slightly lower (data not shown). The AUCs were similar after 6 and after 12 months of followup (6 months: AUC: 0.65, 95% CI: 0.57−0.73). These results suggest that the predictive validity of the LASA fall risk profile is similar on the short-term and on the long-term.

Which cutoff value should be used depends on the purpose of the screening. On average, the optimal cutoff value is eight: at this value, the maximum sum of sensitivity and specificity was obtained. However, at this cutoff value the

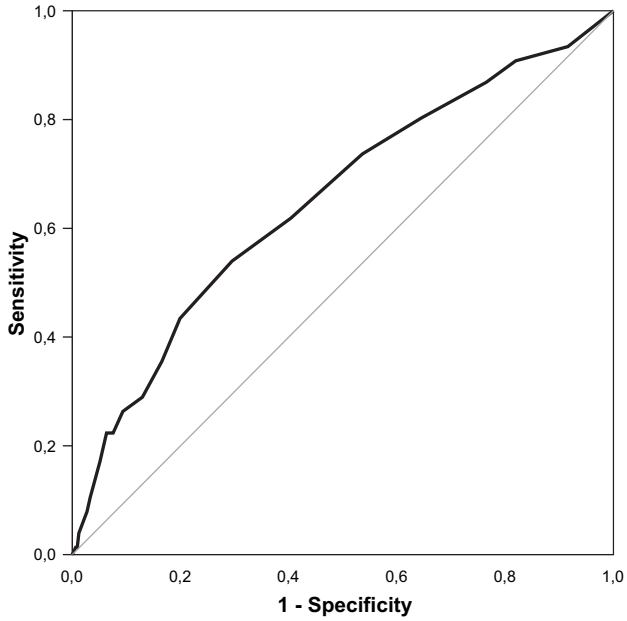

Fig. 2. Receiver operating characteristic curve. The sensitivity on the y-axis is plotted against 1 − specificity on the x-axis for the fall risk profile in the fall prevention trial. The area under the receiver operating characteristic curve is 0.65; confidence interval: 0.58−0.72.

sensitivity was moderate resulting in a higher percentage of misclassification of recurrent fallers. If this risk profile is used to select persons who may benefit from preventive measures, it is important not to miss any of the recurrent fallers. To minimize misclassification, the sensitivity and negative predictive value should be high. Therefore, a lower cutoff value may be used, for example, a cutoff value of five. Note however that lower cutoff values do decrease the specificity and positive predictive values as a result of which too many persons will be referred to the prevention program. Internationally, fall prevention guidelines recommend multidisciplinary evaluation and tailored treatment of fall risk factors. Among low-risk persons who are incorrectly classified as high risk and referred to a fall clinic, the evaluation will probably reveal fewer risk factors, and consequently the treatment will be simple and cheap. At much lower cutoff values, too many persons will be referred to the prevention program and one may question the added value of screening before referral and the cost-effectiveness of the screening plus intervention.

The results of this study show that the discriminative ability of the LASA fall risk profile is only a little higher than prediction based on chance alone in persons who sought care after a fall. However, the discriminative ability in the present study was similar to that of the FROP-Com, which was applied to a comparable population [14]. The FROP-Com is a screening tool that consists of 26 questions and predicts the risk of falling [14]. The population of presenting fallers seems to be a relatively homogenous group, in which it is difficult to discriminate occasional fallers from recurrent fallers. Given the serious consequences of falling in older persons, each percentage gain in the discriminative ability is important. The predictive value may be improved by adding other predictors that were not included in our study but have been shown to be of importance in other studies as, for example, the use of benzodiazepines or type of last fall (extrinsic/intrinsic) or type of fall-related injury. The current risk profile was developed in an unselected population. The predictive validity is likely to be better in risk profiles that are developed in the same population that it is going to be used in, that is, consisting of persons who seek care after a fall. Furthermore, the most important falls that need to be prevented are the falls that result in a fracture or other serious injury. To predict fall-related fractures, risk profiles for falls and fractures should be combined and validated. Finally, it would be interesting to compare the predictive validity of various risk profiles with clinical judgment.

The items in the LASA fall risk profile are predictors of recurrent falling but do not necessarily have a causal relationship with recurrent falling. Consequently, the items do not directly provide directions for treatment. For example, having a cat or a dog does not mean that patients need to remove the pet from the household because having a pet may also have positive influences on health, such as social contacts and physical activity. To prevent misinterpretation by patients, the risk profile should be assessed by trained interviewers who are able to take away any potential concerns following the questions.

The strength of the risk profile is its feasibility. After a short instruction, the profile is easy to administer. The time needed to complete the risk profile is approximately 10 minutes. Furthermore, few attributes are necessary (i.e., a weighing scale and grip strength dynamometer). The profile can be further simplified by replacing the FES with the question ‘‘Are you afraid to fall?’’. Other risk profiles, such as the short version of the FROP-Com [14], the Fall Risk Assessment Tool [26], and an earlier LASA screening test [13] may be even easier to administer because no attributes are needed in these tools. However, the predictive validity of these tools needs to be examined in a care-seeking population. An important limitation of this study is that half of the participants with scores of 8 and higher on the LASA fall risk profile were excluded from the current analysis. These participants were excluded because the treatment effect in this intervention group is not yet known and may influence the results. This may have led to an underestimation of the sensitivity and overestimation of the specificity over the full range of cutoff points. A sensitivity analyses in which the intervention participants were included showed that the AUC was 0.67 (CI: 0.61−0.73). The score of 8 remained the optimal cutoff value with a sensitivity of 63.0%, a specificity of 63.3%, a positive predictive value of 32.1%, and a negative predictive value of 86.1%. Excluding the intervention participation did not change the discriminative ability. A second limitation is that the results cannot be generalized to the general population. However, the current sample is a population in which case finding for fall prevention is relevant. To evaluate the validity of this risk profile in different populations, further research is necessary. Finally, 9% of the participants had incomplete followup and had to be excluded from the analyses. These participants were older and scored higher on the fall risk profile. It is likely that the fall rate in this group would be higher, which may have resulted in either an overestimation or an underestimation of the discriminative ability in the FPT.

In conclusion, the discriminative ability of the LASA fall risk profile was moderate. The predictive validity of the LASA fall risk profile to identify recurrent fallers is limited among older persons who consulted the emergency department or general practitioner after a fall.

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Supplementary information

Supplementary data associated with this article can be found, in the online version, at 10.1016/j.jclinepi.2009.12.012

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